PILOT TRACKING FOR SYNCHRONIZATION USING CORRELATION BETWEEN DIGITAL SIGNAL AND LOCALLY GENERATED VERSION OF PN SIGNAL

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part under 35 U.S.C. § 120 of copending U.S. Ser. No. 60/130,088, filed Apr. 20, 1999, now pending, the entire contents of which are hereby incorporated herein by reference as if fully set forth herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates generally to the field of code division multiple access (CDMA). More particularly, the invention relates to CDMA pilot tracking for synchronization.

2. Discussion of the Related Art

Cellular telephony based on CDMA operates in two frequency bands in the US. The first band is the regular cellular band wherein base stations transmit using RF carrier frequencies of approximately 870 MHz. The second band is the PCS band wherein base stations transmit using RF carrier frequencies of approximately 1960 MHz. The principles of CDMA are well known and detailed specifications are established.[1-3]

Fundamental to the operation of CDMA is the notion of the pilot channel which is transmitted by the base station. The sole purpose of the pilot channel is to allow the mobile station to acquire synchronization which is a prerequisite for extraction of any data (such as encoded speech). All CDMA base stations derive their timing from GPS (global positioning system) signals. Thus, any timing derived from the base station transmitted signal, namely the pilot channel is traceable to the GPS, provided the base station is not in a holdover mode of operation.

The pilot channel is a "constant" signal which, because of its deterministic nature, is suitable for acquisition and tracking. The "information" carried by the pilot channel is solely that of timing. It is generated by modulating a constant pattern onto the RF carrier. The construction of the pilot channel is depicted in FIG. **1**.

The pilot channel is obtained by taking a constant pattern (e.g., all−1s) and spreading it using the I-channel and Q-channel PN (Pseudo Noise) sequences which have a chip-rate of 1.2288 Mcps. For convenience, the chip values are chosen as +1 and −1 though in an actual digital implementation the values would correspond to a logic-1 and logic-0, respectively. Following the spreading operation, the I and Q impulses are processed by identical baseband filters which provide the bandwidth limitation (intentional inter-symbol-interference) and pulse shaping functions. The I and Q channels are modulated onto the in-phase and quadrature RF carriers and summed to create the pilot channel signal s(t). The pilot channel and other channels (speech, paging, synchronization., etc.) are combined as a weighted sum so as the create the composite transmit signal whose power is nominally a constant. Thus, depending on the traffic, the radiated signal power associated with the pilot signal can be variable. Normal practice is to ensure that the pilot signal power is at least 10% of the radiated power.

The properties associated with the pilot channel are reflected directly in the ability of a receiver to extract proper synchronization. The fundamental aspects of the pilot channel are discussed below.

The I-channel and Q-channel PN sequences are periodic "noise-like" sequences which have a period of 2^{15} chips. They are derived from PRBS (pseudo-random binary sequence; also referred to as maximum length linear feedback shift register sequences) which can be generated using 15-bit shift registers with appropriate feedback. A PRBS sequence has a period of $(2^{15}-1)$ bits (i.e. chips) and is characterized by having strings of 1s of all lengths upto 15 but strings of 0s up to length 14. A PN sequence is created from the underlying PRBS sequence by inserting an additional 0 after the string of 14 zeros, which occurs only once per period in the PRBS. The period of the PN sequence is thus one more than the PRBS, or 2^{15} bits (chips).

In IS-95 CDMA, the maximum length shift register sequences from which the PN sequences are derived are specified by the recursion relations:

$$i(n)=i(n-15)\oplus i(n-10)\oplus i(n-8)\oplus (i(n-7)\oplus i(n-6)\oplus i(n-2)$$

$$q(n)=q(n-15)\oplus q(n-12)\oplus q(n-11)\oplus q(n-10)\oplus q(n-9)\oplus q(n-5)\oplus q(n-4)\oplus q(n-3)$$

where i(n) and q(n) are binary-valued ('0' and '1') and the additions are modulo-2. The '0' inserted after the 14-th zero of the string of 14 consecutive zeros in the PRBS is, by definition, the "last" bit of the period; the subsequent '1' is considered the first bit of the next period. The start of this first bit (chip) interval is aligned with CDMA system time.

The correlation between two sequences, $\{\alpha(n)\}$ and $\{\beta(n)\}$, where $\{\alpha(n)\}$ is assumed to be periodic with length N (bit-times), is defined as

$$R_{\alpha\beta}=\sum_{n=0}^{N-1}\alpha(n)\cdot\beta(n)$$

This can be extended to the notion of an auto-correlation sequence and a cross-correlation sequence if it is assumed that the periods of the two sequences are the same. These extensions take the form

$$R_{\alpha\alpha}(k)=\sum_{n=0}^{N-1}\alpha(n)\cdot\alpha(n-k)$$

$$R_{\alpha\beta}(k)=\sum_{n=0}^{N-1}\alpha(n)\cdot\beta(n-k)$$

where the correlation lag, k, indicates the delay introduced for the second sequence prior to computing the correlation.

PRBS sequences, generated using linear feedback shift registers, have an especially nice auto-correlation property. In particular, if $\{\alpha(n)\}$ is a PRBS sequence of length N=2K−1, and the values are treated as +1 and −1 (for '1' and '0'), then the sequence $R_{\alpha\alpha}(K)$ will be two-valued (and of course periodic) with $R_{\alpha\alpha}(K)=N$ for k=0 and $R_{\alpha\alpha}(K)=-1$ for other values of correlation lag. That is, the auto-correlation sequence is (approximately) a Kronecker Delta function. This is the basis for considering such sequences "white-noise" or "white-noise-like." Furthermore, the cross-correlation between two different PRBS sequences of the same length is approximately zero. Extending the PRBS sequences to the PN sequences by inserting an extra '0' (or −1, depending on one's convention) does not alter the auto-correlation and cross-correlation properties to any great